Fig. 4. *Halichondria scabida*, outline of the specimen and its spiculation &c. *a*, outline of the specimen ; *b b*, pore-areas ; *c*, part of the dermis without pore-areas : *d*, skeletal spicule ; *e*, subskeletal spicule ; *f*, still smaller form ; *g*, large form of equianchorate ; *h*, small form of the same ; *i*, more magnified view of large form, to show the teeth, arms, or flukes, as they have been called, of the extremities ; *k*, pore-areas magnified four diameters ; *l*, rim ; *m*, pores ; *n*, still more magnified view of the pores in a fragment of the sarcode charged with the small form of anchorate (*h*) ; *o*, pores ; *p*, sarcode charged with the anchorate.

Fig. 5. The same. Diagram to show the *direct* connexion of the pore-areas with the excretory canal. *a*, pore-areas ; *b*, subdermal cavities or structure ; *c*, excretory canal ; *d*, circular folds, more or less extending round the surface of the excretory canal ; *e*, apertures of the smaller branches in this canal ; *f*, filament introduced to show the *direct* communication of the pore-areas with the excretory canal ; *g*, vent, with arrow showing the direction of the current.

Fig. 6. *Acanthella cactiformis*, spiculation of. *a*, acuate form ; *b*, acerate form.

Fig. 7. See explanation in connexion with the paper which it illustrates, p. 122.

XI.—*Mode of Circulation in the Spongida.* By H. J. Carter, F.R.S. &c.

[Plate IV. figs. 5, *a–g*, and 7, *a–p*.]

In the month of July 1857, when my observations "On the Ultimate Structure of *Spongilla*" were published ('Annals,' vol. xx. p. 21, pl. i.), I thought there could be no doubt about the course of the circulation in the Spongida, as the minute portion of *Spongilla* developed from the statoblast (gemmule or seed-like body) is so small and yet so perfect that it can be easily kept under the microscope, while the red particles of carmine-paint that may be brought into contact with it are taken in and discharged before the eye. By being "so perfect," I mean that it consists of only one "person" (Häckel), that is, it is a minute epitome of sponge-structure in which there is only one vent and therefore only one excretory canal-system ; hence a view of the whole portion which is translucent can be easily commanded by the aid of a microscopic power of 250–300 diameters (in water of course).

Under such circumstances (I must here revert to my original nomenclature and diagram, *op. et loc. cit.* pl. i. fig. 1) the particles of carmine-paint may be seen to pass through the holes of the "investing membrane" (pore-dermis) into the so-called "cavity" of this membrane (subdermal cavities), and from thence into the parenchyma or semiopaque structure of the body, where they finally come into contact with the spongozoa ("Geisselzellen") of the ampullaceous sacs ("Geisselkammern"), and there rest for about fifteen minutes, when there is a cessation of the circulation, during which the vent is closed and the tubular process on which it was projected is retracted. After the expiration of the time mentioned the "tubular process" is again put forth, and the vent at the end of it opened, when the red particles, now probably separated from their gummy constituents, may be seen to pass from the ampullaceous sacs into the large branches of the excretory canal-system, and so finally out at the vent.

All this is plain; but as stated (*l. c.*) I could not follow the particles from the cavity of the investing membrane through the parenchyma, although I could see when they arrived at the ampullaceous sac, and by tearing the latter to pieces, that the spongozoa had finally taken them into their bodies.

This view continued in much the same state until 1877, when Dr. F. E. Schulze, of Gratz University, began to publish those illustrated descriptions in the Zeitschr. f. wiss. Zool. which have made a notable epoch in the advancement of spongology (Bd. xxviii.–xxxv.), wherein he shows that, in *Halisarca lobularis* (Bd. xxviii. Taf. ii. fig. 13), there is a *plurality* of small holes in the ampullaceous sac, and especially in *Spongelia avara* (Bd. xxxii. S. 134, Taf. viii. fig. 5), where "20–30" might be numbered in addition to the large aperture which communicates directly with the branch of the excretory canal-system; while in the Chondrosidæ, the Aplysinidæ, and *Corticium candelabrum* only two apertures are represented, viz. an afferent and an efferent aperture. Schulze also pointed out in 1875 that similar small apertures existed in the chamber-walls of *Sycandra raphanus* (Bd. xxv. Suppl. Taf. xviii. fig. 1).

Thus it might be inferred that there is a distinct pore-system which carries the particles of nutriment *direct* from the dermis to the spongozoa, as direct as that which takes them away; but this we shall see is not so, for the particles that are taken in with the water through the pores of the dermis fall *directly* into the subdermal cavities, and pass thence into the large excretory canals, from which they are afterwards *deflected* to their destination through smaller branches, whose apertures may be seen in the walls of the former (Pl. IV. fig. 5, *e*).

This I pointed out in 1869 ('Annals,' vol. iv. p. 192, pl. vii. fig. 5) in *Grayella cyathophora*, where the pore-area, which is pustuliform and circumscribed on the surface, opens through the subdermal cavities *directly* into a large branch of the excretory canal-system, so that the particles of nutriment which enter the sponge with the water must be deflected afterwards by some means through the small canals (fig. 5, *e*) which branch off from the larger excretory canal, and thus do not reach their destination "direct," as above stated.

There is evidently then a selection here, and probably another when the particles arrive at the spongozoa in the cavity of the ampullaceous sac, where the afferent and efferent currents meet and where there must also be another selective separation, by which the excrementitious particles are drafted back into the excrementary canal. I have pointed out this too in *Axos spinipoculum* ('Annals,' 1879, vol. iii. p. 287, pl. xxv. figs. 4, 5, &c.); but my attention has been more particularly drawn to it lately by anatomizing the structure of some South-Australian sponges dredged in the neighbourhood of Port Phillip Heads in January last, which were preserved in spirit through having been directly thrown into the latter as they were brought up in the dredge by Mr. J. Bracebridge Wilson, M.A., F.L.S., of the Church of England Grammar School, Geelong, who kindly obtained and sent them to me.

This perhaps is best seen in *Teichonella labyrinthica* ('Annals,' 1878, vol. ii. p. 37, pl. ii. fig. 6 &c.), wherein the chambers (Pl. IV. fig. 7, *a*–*p*), which are arranged in juxtaposition perpendicularly to the lamina of which the sponge is composed, thus pass directly through it from one side to the other, having therefore on one side the pores or pore-dermis (fig. 7, *b*), and on the other the vent (fig. 7, *i*); in short exactly like those of *Grantia compressa*, only there is no cloaca *. We must, however, regard this chamber as at once ampullaceous sac and excretory canal; for the pore-dermis being at one end or side of the lamina and the vent at the other, the circulation passes into the former and out at the latter, through the chamber, where the nutritive particles are instantly taken up by the spongozoa lining its cavity (fig. 7, *h*). Hence the holes in the walls of the chamber (fig. 7, *g*), which are very numerous, may serve for the purpose of intercommunication, where the walls of the neighbouring chambers are in direct contact with each other, or for the purpose of allowing

* I find by the spirit-preserved *Teichonella labyrinthica* (for there are fine specimens of both *T. prolifera* and *T. labyrinthica* in Mr. Wilson's collection) that in my original description of the latter (*op. et loc. cit.*) I have omitted to notice the quadriradiate spicule, which, of course, still more closely allies it to *Grantia compressa*.

the ova developed in the intercameral tissue (fig. 7, *n*, *o*) to pass into the chamber and thus be expelled. Therefore these holes would seem to have more functions than those ascribed to them in the wall of the ampullaceous sac of the so-called "siliceous sponges," ex. gr. *Spongelia avara* (Schulze, *l. c.*).

Returning to the latter then I find two undescribed species of my order Psammonemata among Mr. Wilson's dredgings, in which what I have above stated respecting the mode of circulation is particularly well illustrated, not only on account of the fact itself, but on account of its being present in two totally different structures. These species, which I have respectively named *Geelongia vasiformis* and *Hircinia solida*, will be more particularly described in another paper for future publication, but may here, for convenience, be briefly noticed as follows :—

Geelongia vasiformis.

Vasiform, stipitate, 6½ inches high by 6 inches across the brim, diminishing to the stem, which is 2½ inches long and 1¼ inch in diameter, ending in a root-like expansion; with a thickness of wall at the bottom amounting to 5-8ths inch, diminishing gradually to the brim, which is even and round; covered externally by a thick dermal layer of sarcode charged with sand, in which are the pores and a few small scattered vents; and internally, with a layer of the same kind, in which there are larger vents *alone*, that is with no pores, which are numerous and, in one specimen, uniformly spread over the *upper half only* of this surface, the lower part being entirely smooth. *No* conuli on either side.

Hircinia intertexta.

Compressed, oblong, flat, sessile, 12 inches high by 6 inches wide, with irregularly undulating, rounded margin on all sides, and a thickness of 1½ inch below, which diminishes to about ¾ inch in the upper part; covered on both sides with a soft, reticulated, dermal layer of sarcode *without foreign bodies*, in the interstices of which the pores are situated, the whole being thrown up into obtuse conuli or monticular elevations, in bold relief, by the projection of the subjacent keratose fibre; and the vents, which are small and scantily scattered over both sides, are largest and most numerous on the upper border. Conuli on both sides.

With these two distinct forms come two distinct arrangements of the internal structure—that is, in *Geelongia vasiformis* the direction of the fibres and the excretory canals is across or perpendicular to the planes of the wall; while in *Hircinia solida* it is the opposite, that is, they are longitudinal or parallel to them. Hence in the former the great excretory canal runs from the pore-surface or subdermal cavities on one side to the vents on the other, much as the "chamber" in *Teichonella labyrinthica*; while in *Hircinia solida* the great excretory canals run along the whole length of the sides *just under* the subdermal cavities, more like those in *Teichonella prolifera*, finally opening at the large vents in the upper end or border; but in their course sending off in both instances small canals transversely into the sponge-structure (*ex. gr.* Pl. IV. fig. 5, *e*). Thus, in both cases also, the great excretory canals first receive the water and its nutrient particles from the pores through the subdermal cavities, when the latter, at least, are deflected through the small lateral canals just mentioned, to the spongozoa and ampullaceous sacs. From this point to the ampullaceous sacs they have yet to be traced.

Although it may be inferred that each pore-hole in the ampullaceous sac of *Spongelia avara*, as represented by Schulze (*l. c.*), is connected with an afferent, tubular canal, this is only represented in that of *Halisarca lobularis* (*l. c.* Taf. ii. fig. 13), but its further continuation (that is, its connection with the branch coming from the great excretory canal) has yet to be shown; although the efferent opening in the ampullaceous sac, which is connected with the excretory canal, on the other side, was verified by myself, as above stated, from the commencement ('Annals,' *l. c.*).

We might now appropriately consider how the rush of water through the great excretory canals is produced, viz. whether it is effected by the cilia of the epithelial cells only, or by some other means, or by both. The other means to which I allude is the presence of circular folds more or less extending round the surface of the canal, which are not induced by the presence of the apertures on the surface, since they often occur without this, as may be seen by the illustrations of *Grayella cyathophora* and *Axos spinipoculum* respectively ('Annals,' 1869, vol. iv. pl. vii. fig. 5, *g*, *h*, *i*, and 1879, vol. iii. pl. xxv. fig. 5), while, of course, the presence of the folds alone would be no indication of their having any effect upon the circulation, had it not been proved by dissection in the spirit-preserved specimen of *Axos spinipoculum*, wherein the excretory canal-system is strongly developed, that the wall of the excretory canal is composed of two layers like that of the human intestine, viz. an epithelial layer of cells (*l. c.* pl. xxv.

fig. 9), and underneath this a layer of ?-muscular fibrillæ partly longitudinal and partly transverse (fig. 6).

Thus, assuming that the cells had been monociliated they must have had some office; while assuming that the fibrillous layer was muscular (and I do not see what else it could have been), this would have the effect of circular and longitudinal motion respectively. Hence, supposing that the circular folds, more or less extending round the surface, were influenced by this motion, it would have the same effect upon the contents of the excretory canal as that of the intestine upon its contents, which would be to propel them onwards to the vent (or the reverse, if necessary), and thus resemble the "*valvulæ conniventes*" of the latter. Of course, the transverse and longitudinal fibrillæ of the excretory canal can no more be expected to be identified by the so-called "*striped*" appearance than the muscular fibres of the intestines.

Still, it might be observed that, although this can be demonstrated in *Axos spinipoculum*, it may not be the case in other sponges; but if we are to deny the existence of motory structure in moving objects because it cannot be demonstrated by the highest microscopic powers, we might as well deny that there is any structure in glass because it is transparent!

EXPLANATION OF PLATE IV.

Fig. 5. *Halichondria scabida*, diagram showing the direct connection of the pore-areas with the excretory canal. *a*, pore-areas; *b*, subdermal cavities; *c*, excretory canal; *d*, circular folds, more or less extending round the surface of the excretory canal; *e*, apertures of branches in this canal; *f*, filament introduced to show the direct communication of the pore-areas with the excretory canal; *g*, vent.

Fig. 7. *Teichonella labyrinthica.* Perpendicular section of a chamber, with all its parts drawn to scale, viz. about 1-48th to 1-1800th inch, the arrows indicating the direction of the circulation. *a a*, Chamber; *b*, pore-dermis, leading into *c*, subdermal cavity, and the latter leading *into* "*a a*," the chamber; *d*, subdermal tissue; *e*, surface view of pore-dermis; *f*, opening of subdermal cavity, as seen through the pore-dermis; *g*, pores in the wall of the chamber; *h*, spongozoa in the same; *i*, vestibule of the vent; *k*, sphincter of the vent and opening through the same, shown by the arrow; *l*, interoscular tissue; *m*, end view of sphincter, surrounded by interoscular tissue, and arrow showing the direction of the current; *n*, diagram, to show horizontal section of the chambers in their natural position, with the intervals between them; *o*, chambers; *p*, intervals or intercameral tissue in which the ova are developed, and in which the branches of Häckel's "intercanal system" are situated.